Mangrove Restoration and Management in Djibouti:

Criteria and Conditions for Success

Deidre B. Witsen
December 17, 2012

Virginia Polytechnic Institute and State University
Master of Natural Resources
Major: Natural Resources

Graduate Committee:
Dr. Heather Eves (Chair), Dr. Jennifer Jones, and Dr. Steven R. Sheffield

Keywords: Mangroves, mangrove restoration, mangrove management, hydrological connections, habitat degradation, biodiversity

Abstract

The country of Djibouti, while faced with poverty, political instability, lack of human and financial capacity, health issues, a growing population, and water and food insecurity, has some important opportunities to implement a variety of different conservation projects. Mangrove restoration and management is one such endeavor that could result in a multitude of environmental, social, and economic benefits to the coastal communities of Djibouti. This paper provides background on the biodiversity and conservation goals of Djibouti, details general information about mangroves, explains the benefits that mangrove forests can provide, lists threats to mangrove forests, and discusses the state of mangroves in Djibouti. Next, through a case study approach, this paper summarizes other countries' efforts regarding mangrove restoration and management projects and details some specific criteria and conditions for Djibouti to consider. Some of the most important items for Djibouti to take into account when implementing a mangrove restoration and management project are: the selection of appropriate sites that can support a mangrove forest; the restoration of hydrological connections to impounded mangrove areas; utilization of existing knowledge by including communities in planning; coordination between groups conducting mangrove ecosystem restoration and local administration; leadership and government that supports conservation; laws and regulations that enable enforcement of protected areas; clearly stated goals and achievable and measurable success criteria which should be defined and incorporated into a monitoring program; and the importance of having a history and understanding of why the mangrove forest became depleted.

Introduction

Background to Writing of this Paper

As part of the required major paper in pursuit of a Master in Natural Resources, in the spring of 2012 this author completed a FAA 118-119 Analysis: Conservation of Tropical Forests and Biological Diversity for the country of Djibouti (see Appendix A). This was produced for the U.S. Department of Agriculture's Forest Service International Programs to inform the U.S. Agency for International Development of current tropical forestation and biodiversity trends in Djibouti. The U.S. Foreign Assistance Act (FAA) of 1961, as amended by Sections 118 and 119, requires that all USAID Missions conduct a periodic country analysis of the conservation and sustainable use of tropical forests and biological diversity. Specifically, FAA Sections 118 and 119 require that all country plans include:

1. an analysis of the actions necessary in that country to achieve conservation and sustainable management of tropical forests (118) and conserve biological diversity (119); and
2. the extent to which current or proposed USAID actions meet those needs

By mandating these analyses, the United States Congress is recognizing the fundamental role that tropical forests and the conservation of biodiversity play in sustainable development. The protection of the environment and wise management of natural resources is necessary for any successful development program. These analyses help to guide a country's proposed USAID programs toward a more sustainable use of the country's renewable natural resources.

The FAA 118-119 analysis uncovered a variety of actions that Djibouti could implement to conserve biodiversity and tropical forestation. To complement that analysis this paper details one important conservation action that Djibouti could consider. Depletion of mangrove forests was found to be one of the main threats to biodiversity in Djibouti. Therefore, this paper was written to discuss criteria and conditions for Djibouti to consider in order to achieve a successful mangrove restoration and management project.

There are several items to note when reading this paper. First, while this author found there are many different sources reporting information about Djibouti, different sources often report different statistics and information. In addition, some important, specific information was difficult to ascertain such as the status of protected areas in Djibouti and a consistent estimate for the population of Djibouti. These numbers ranged from approximately 600,000 to 900,000. According to a conversation with a field professional with knowledge of Djibouti on 15 November 2012 the varying statistics are partially due to the fact that surveys are most often given in English or French. However, the majority of the Djiboutian population speaks either Somali or Afar resulting in survey data that may not be accurate. Therefore, this author found difficulty with doing desk-top research only for a country such as Djibouti since accurate, "on the ground data" is difficult or impossible to obtain. Consequently, the recommendations in this paper are based upon the best information that this author could find during the time that research was conducted.

Background on Djibouti and biodiversity conservation goals

Situated in the Greater Horn of Africa and bordered by Eritrea, Ethiopia, and Somalia, Djibouti has a land area of 23,200 km^2 and an estimated population of 889,000 (UNDESA 2010). The majority of the country is desert with a dry, torrid, and unusually hot climate (CIA 2012). Furthermore, Djibouti often faces drought conditions and is currently in its seventh consecutive year of drought (U.N. 2011).

While this desert land supports a surprisingly large number of species, including 826 species of plants and 1,417 species of animals, it has been also described as having a lack of natural resources due to limited arable land, desertification, no permanent fresh water source, and limited vegetation (Brass 2008). Much of the biodiversity is found in the forests, which are primarily in the north and which comprise less than 1% of the total land, and in the coral reefs and mangroves located along the coasts. The discrepancy in the literature between having a lack of natural resources versus having high levels of biodiversity is possibly due to the majority of the country being a desert with biodiversity found primarily only in small pockets in the forests in the north and along the coast.

Figure 1: Map of Djibouti

Source: United States Department of State 2012

Threats facing the conservation of biodiversity and tropical forests in Djibouti include the following: habitat degradation; drought and desertification; climate change; pollution; invasive species; political instability; health issues; population growth and urban development; poverty, unemployment and lack of a skilled workforce; a continued influx of refugees; lack of financial capacity; limited governmental, institutional, and legal capacity; and food and water insecurity (CIA 2012; CBD 2012; USAID/REDSO 2005). The combination of the social and economic factors listed above tend to result in difficulty in addressing direct threats to mangroves such as deforestation, pollution and improper waste disposal, and overexploitation of coastal and marine resources.

The FAA 118-119 Analysis: Conservation of Tropical Forests and Biological Diversity for the country of Djibouti (Appendix A) provides details of the political and social challenges facing Djibouti particularly as it relates to natural resources conservation. Political instability exists in the country primarily due to the authoritarian nature of its government and a lack of trust on the part of its citizens due to its non-transparency and unilateral Presidential Decree.

While Djibouti has shown an interest in conservation and biodiversity and has become a party to many environmental treaties and conventions, their follow-through has not been sufficient to achieve most of their conservation goals and objectives. For example, seven years after adoption of the National Biodiversity Strategy Action Plan only 10 out of 33 projects had been implemented in Djibouti (CBD 2009). The Conservation on Biodiversity National Reports for Djibouti indicate that this was due primarily to financial and human capacity constraints. For instance, the environmental sector of the government receives only a small part of the budget.

Mangrove restoration was chosen as an important conservation project for Djibouti to consider for a variety of reasons. First, one of the national objectives for Djibout is to conserve biodiversity in-situ in zones of ecological significance. Next, monitoring of marine pollution and

the protection of natural sites that are important for tourism are also items of concern. Furthermore, a priority area for Djibouti is to maintain the integrity of ecosystems and their ability to provide essential services. Finally, mangrove habitats were found to be one of three habitats that are most threatened in the country (CBD 2001; CBD 2002a; CBD 2006; CBD 2008; CBD 2009).

A literature review has revealed that there have been recent successful mangrove rehabilitation projects throughout the world that are community driven and require limited financial resources. In addition, studies reveal that the Gulf of Aden and the Red Sea will be affected by rising seas and Djibouti sits along these bodies of water. Hence mangroves are important to Djibouti due to the climate change adaptation benefits that they provide. These include their ability to protect coastal areas from rising seas and their ability to trap large amounts of carbon from the atmosphere. Therefore, this paper will attempt to answer the following research question: ***"Based on social, economic, environmental and political factors as well as scientific evidence described by managers in similar ecosystems, what are some criteria and conditions that will help lead Djibouti to successful mangrove restoration and management?"***

General Information on Mangroves

Worldwide mangrove loss and habitat degradation has become a major concern for many countries especially since the Indian Ocean tsunami in 2004 when the importance of mangroves for coastal protection came into focus (Tamin et al. 2011). Mangroves are critically important for a multitude of other reasons. First, they help to support biodiversity conservation. Despite there being just 10 different species of mangroves trees in East Africa, their ecosystems host a wide variety of biodiversity and they are considered to be one of the most productive ecosystems on Earth (Carrere 2009). Next, they provide important ecosystem services. Eighty percent of commercial fisheries and other aquatic species spend a large portion of their life cycle in mangroves. They play a crucial role in fertilization, stabilization, filtration, regulation of microclimates, act as a food chain support, and act as a nursery for fish and invertebrate species (WRM 2008). They also act as a natural barrier between coastal storms and homes and provide coral reef protection (World Rainforest Movement n.d.). Mangroves are important sources of carbon sequestration and many scientists are finding that they are more efficient at trapping carbon than tropical and temperate forests (IUCN 2011). Furthermore, local communities consider them to be highly valuable as many people derive their livelihoods from them since they supply a variety of food sources, especially fisheries (Carrere 2009) and they provide building materials, firewood, tannins, fodder, and herbal medicines (Kairo et al. 2008).

Spalding, Kainuma, and Collins (2010) report that worldwide, mangroves cover approximately 152,000 km^2 (or 37,560,017 acres) throughout 123 countries and territories. The largest areas are found in the Sundarbans of India and Bangladesh, the Niger Delta, West Africa, and the complex deltaic coastlines of Northern Brazil and Southern Papua in Papua New Guinea. Global mangrove distribution is summarized in Table 1.

Table 1. Worldwide distribution and size of mangrove areas

Region	Area (km^2)	Proportion of Global Total
East and South Africa	7,917	5.2%
Middle East	624	0.4%
South Asia	10,344	6.8%
South-East Asia	51,049	33.5%
East Asia	215	0.1%
Australasia	10,171	6.7%
Pacific Ocean	5,717	3.8%
North and Central America	22,402	14.7%
South America	23,882	15.7%
West and Central Africa	20,040	13.2%
Total	**152,361**	

Source: Spalding, Kainuma, and Collins 2010

While the percentage of global mangrove loss per year has been decreasing, the losses since 1980 have been considerable and are continuing. FAO (2007) reports that approximately 35,600 km^2 (or 8,796,951 acres) were lost between 1980 and 2005. Furthermore, while there is no accurate data of original mangrove cover, it is believed to have been close to 200,000 km^2 and about 50,000 km^2 or 25% of all mangrove forests have been lost due to human activity (Spalding, Kainuma, and Collins 2010).

Threats to Mangroves

According to PERSGA (2004a), Mangroves in the nations that have coasts along the Red Sea and Gulf of Aden, such as Djibouti, face threats specific to their location since this region is one of the major thoroughfares for maritime traffic between Asia-Pacific and Europe. Often the shipment of oil occurs in this thoroughfare. Consequently the threats to these mangroves include: risk of ship collision and grounding in major traffic lanes; discharge of sewage; discharge of solid waste; oil spills; and illegal disposal of toxic wastes (PERSGA 2004a). Climate change has also been found to impact mangrove ecosystems due to rising sea levels (Mukhtar and Hannan 2012).

Threats specific to mangroves in Djibouti include: camel grazing; mangrove cutting; mass tree mortality of mangrove trees and 'top dying'; pollution; and construction activities (PERSGA 2004b). Details of these threats are described under "Mangroves in Djibouti."

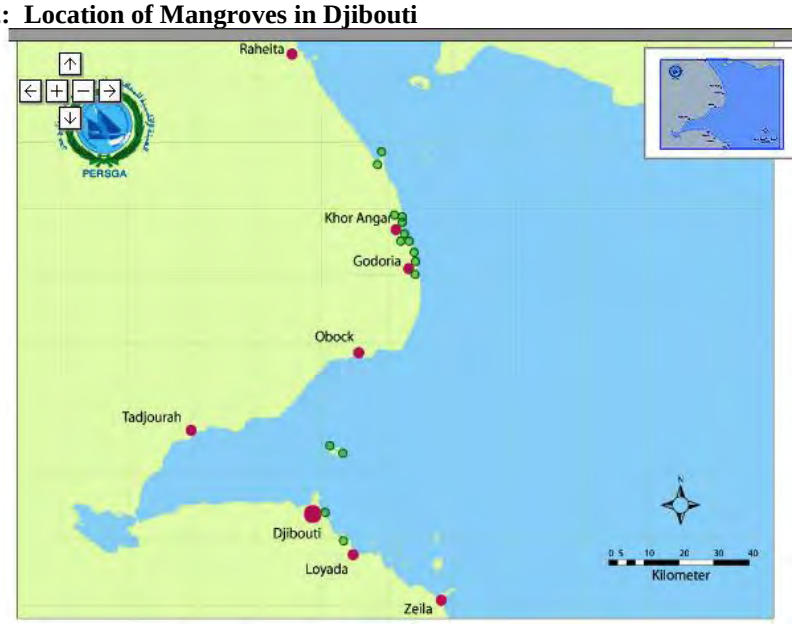
Furthermore, there are several indirect threats which may be contributing to the direct threats listed above. Population growth in general and a human migration to the coastal areas of

Djibouti has resulted in there being more demand for mangroves for firewood and building material and settlements in areas that could become inundated. The population growth and increased tourism have resulted in an increase in pollution especially in terms of sewage and solid waste. The expanding tourism has also added to degradation of the mangrove habitat and coastal erosion. Additionally, there is inadequate enforcement capacity for the Marine Protected Areas of Moucha and Maskali Islands (Adhikari, Baig, and Iftikhar 2010, IGAD 2010).

Mangroves in Djibouti

Seven significant mangrove forests are found in Djibouti along with the associated coastal habitats which support high levels of biodiversity (MHUEAT 2011). Mangrove forests cover 9.96 km^2 (996 hectares) or approximately 2,461 acres of land in Djibouti which represents just 0.04% of the total land (Spalding, Kainuma, and Collins 2010). FAO (2011) reports that about 60 km^2 (6,000 hectares) or approximately 14,826 acres, which is just less than 1% of the land area in Djibouti, is forested. Therefore, mangroves represent 16.5% of the forested land.

Figure 2: Location of Mangroves in Djibouti



Source: PERSGA 2008

Figure 3: Location of Ras Siyyan, Khor Angra, and Iles Moucha (Moucha Island), Djibouti

Source: Spalding, Kainuma, and Collins 2010

One hundred percent of forests in Djibouti are in public ownership (Mongabay.com 2010). Therefore, there is no private land tenure of any forest in Djibouti. According to a field professional with knowledge of Djibouti on 17 October 2012, the government of Djibouti does allow some limited sustainable use of protected forests. However, no mangrove forests are currently legally protected in Djibouti.

The Environment Unit at The Ministry of Housing, Urbanism, Environment and Land Use Planning (MHUEAT) oversees environmental matters in Djibouti. The goal of the unit is to provide an integrated approach to tackling environmental issues (PERSGA 2012). According to PERSGA (2004a), Djibouti has 31 national laws, regulations, orders and decrees that address the protection of coastal and marine environments. In addition, they have ratified numerous regional and international conventions and agreements (see Appendix A for specifics). However, the challenge for Djibouti is that due to a lack of understanding and recognition of these conservation efforts by the general public and members of the government, implementation of the environmental legislation has been inhibited.

While the total area of mangrove coverage in Djibouti may seem small, its relationship to the size of the country is substantial. Since forest cover is so limited in this country, mangroves consequently provide necessary resources for the local communities and habitat which supports a wide range of biodiversity (FAO 2007).

Approximately 100% of the population in Djibouti is considered to live in the coastal zone range, due to the country being narrow with the furthest areas being no more than approximately 100 miles from the coast (IGAD Environment Outlook 2010). Since the 1980s, no major changes in the size of mangrove areas have been reported in Djibouti. However, this lack of mangrove loss may not necessarily be a success; it may instead be due to a lack of recent, reliable quantitative information (FAO 2007).

According to FAO (2007), two different species of mangroves primarily exist in Djibouti, *Avicennia marina* and *Rhizophora mucronata*. *Avicennia marina* is the most abundant species and is reported in all mangrove areas in Djibouti. *Rhizophora mucronata* co-exists with *Avicennia marina* in three areas. Additionally, *Ceriops tagal* and *Bruguiera gymnorrhiza* have

also been found in Djibouti but in limited numbers. Mangroves on the east coast of Africa generally form narrow fringe communities along the shores or small patches in estuaries, along seasonal creeks, or in lagoons (FAO 2007).

The following information, regarding the status of mangroves in Djibouti, was derived from PERSGA (2004b). The health of many of the mangroves in Djibouti has been compromised. In addition, due to the extreme environmental conditions such as high salinity, low rainfall and extreme temperatures, the trees are often stunted in comparison to those in other mangrove forests. In 2004 mangroves were surveyed by PERSGA at seven locations along the coast and islands of Djibouti. Similar types of impacts were discovered in most of these areas. Most impacts were due to actions of those in the local community for their own use rather than for export to other countries. These impacts are summarized in Table 2 and are described below.

Negative effects from camel grazing were found in most of the mangrove stands surveyed. These effects include a reduction in the green parts of the trees, dryness of the uppermost and outermost parts of the grazed branches, limitation of the mangrove growth to stunted, multi-stemmed bushes, and destruction of the seedlings and pneumatophores under the feet of camels. Cutting of mangroves, found in all of the surveyed mangrove stands, is generally done in order to provide firewood for cooking and timber for building housing. Both cutting and camel grazing were found to cause the ground to become denuded which allowed increased erosion and sand movement which can bury the mangrove channels and block water circulation.

Portions of Khor Ahgar experienced mass tree mortality estimated at 35-40% of the total *Rhizophora mucronata* stand. Furthermore, there was an infestation of insects and microbial organisms on the dead trees. These could spread to the dry limbs of living trees which would cause additional stress. Reduced tidal water circulation was found to be due to the massive accumulation of dead wood and leaves in the tidal channels. This situation provided an ideal environment for microbial decomposition. Furthermore, the substantial accumulation of dry wood was found to have used up ground space that young seedlings would need as well as increased the exposure to sunlight which provided unfavorable conditions for seedling growth.

Moucha Island had experienced mass tree mortality of the *Rhizophora mucronata* stand due to sand infilling which blocks the flow of water through the mangrove channels. This deprived some parts of the stand of seawater. Both Moucha and Maskali Islands receive a significant amount of tourist traffic. Unfortunately, due to this they were found to be impacted by improperly handled domestic solid waste which accumulated among the pneumatophores and tree trunks.

The mangroves at Gaan-Mann, located very close to Djibouti town, have been found to be severely impacted. One mangrove stand was found to have at least 50% of its original mangroves removed while the remaining mangroves were stunted. Another stand in this area was under stress due to sewage which was flowing through a short stream that originated from Djibouti town.

The mangroves on Godoria were found to be the most extensive, dense and diverse in Djibouti. It is expected that this was due to the fact that there is limited human activity in the vicinity aside from a sparse population of nomads and a small tourist camp. This limited activity is attributed to the mangrove area being in a remote location that is not easily accessible (PERSGA 2004b).

Table 2: Impacts to surveyed mangrove stands in Djibouti

Location	Type of Impact							
	Camel grazing	Mangrove cutting	Burial by or penetration of sand dunes	Sand sedimentation or infilling	Reduced tidal water circulation	Pollution by domestic solid waste and/or sewage	Pest infestation	Accumulation of dead wood and leaves
Ras Siyyan	√	√	√					
Khor Angar	√	√		√	√		√	√
Godoria	√	√	√					
Obock	√	√						
Moucha Island		√		√			√	
Maskali Island		√				√		
Gaan-Maan	√	√				√		

Source: PERSGA 2004b

Mangrove forests in Djibouti currently are not afforded any designated protection. The only marine protected areas in Djibouti are two areas of coral reefs found around the islands of Maskali and Moucha, called the Moucha Regional Park and the Maskali Reserve, and the 3,000 hectare Haramous-Loyada wetland which has been designated as a Ramsar Wetland of International Importance. However, the mangrove forests at these locations are not protected. The Isles des Sept-Frères and Ras Siyyan located in the Gulf of Aden were identified as being good candidates to be designated as Marine Protected Areas partially due to the presence of extensive mangrove forests on the islands (PERSGA 2004a).

PERSGA has developed a Regional Action Plan (RAP) for the Conservation of Mangroves in the Red Sea and Gulf of Aden. While the status of implementation of the plan is unknown, the plan specifically discusses how mangrove conservation can be maximized through the following activities: Integrated Coastal Zone Management (ICZM) planning for mangroves; education and awareness; development of Marine Protected Areas; ecologically sustainable mangrove utilization; reduction of impacts from shipping and pollution; and research, monitoring, and economic valuation (PERSGA n.d.b).

One effort toward mangrove restoration includes a study by PERSGA for restoration of mangroves at Khor Angar. The goal of this project was to implement Djibouti's first priority identified through its National Adaptation Programme of Action (NAPA) which identified the objective of reducing the vulnerability to climate change (GEF 2008). This is a Global Environment Facility (GEF) supported effort whose projects included an assessment of the mangrove status in Djibouti, the identification of root causes for the degradation and mangrove dry up in significant portions of the forest, an evaluation of previous restoration efforts, specification of sites suitable for hydrological restoration and mangrove planting, suggestions for controlling the increased siltation and protection of the mangroves, and technical recommendations regarding the implementation approach and participation of the local community. The Project Identification Form for this project, originally submitted in 2007 and re-submitted and approved in 2008, indicates that part of the larger project includes mangrove restoration in the north and measures to reduce pressure on mangrove harvesting such as cooking

efficiency, community management of fuel wood, and ecotourism and fishing development around mangroves as incentives. The Least Developed Countries Fund, which was established to support a work program to assist Least Developed Country Parties (LDCs) to carry out the preparation and implementation of national adaptation programs of action, was to have provided $925,000 and indicative co-financing was to have been provided for $570,000 for the overarching project which is to demonstrate and pilot measures that address the root causes of ecosystem vulnerability in key climate change buffering systems. Implementation of this project was to have occurred in August 2009 with a proposed completion date of December 2012 (GEF 2008).

Additionally, the Directorate of Environment in Djibouti has implemented mangrove restoration projects on two sites: the Khor Angar area in the north and the Damerjog area in the south. The emphasis of these projects is on cleaning the mangrove areas and establishment of nurseries to support the replanting activities which targets rehabilitation of 20 hectares of mangroves (MHUEAT 2011 and PERSGA 2012).

Case Studies

During the last 10-15 years an increasing number of communities are participating in restoration and afforestation projects. Restoration projects are those that occur in areas where mangroves have historically grown. On the other hand, afforestation is the term used for planting mangroves in areas where there is no evidence of prior existence (Spalding, Kainuma, and Collins 2010). However, while ecological restoration in general can be challenging, mangrove restoration can be even more so due to the very dynamic nature of the ecosystem. Mangrove ecosystems experience tidal flooding yet need freshwater to balance out the salinity resulting in difficulty in obtaining the best habitat for rehabilitation (Biswas et al. 2007).

The findings of mangrove restoration case studies and their applicability to Djibouti are summarized in Table 3. While the overall climate in many of the countries indicated on the following table differs somewhat from that which occurs in Djibouti, mangrove ecosystems generally share similar climates, especially those that support the same species of mangroves as Djibouti, *Avicennia marina* and *Rhizophora mucronata*.

Table 3: Summary of significant findings of case studies regarding mangrove restoration and applicability of findings to Djibouti

Country	Significant Findings Regarding Mangrove Restoration	Applicability to Djibouti
Malaysia	• Restoration of *Avicennia marina* can successfully occur in accreting shoreline that was previously devoid of coastal vegetation • Hard breakwater necessary when wave height is > 1.5 meters • Planting activities should commence only after ground has been stabilized • Fencing necessary for wildings or planted wild saplings on exposed sites • Tall (1-1.3 m) wild saplings enables rapid greening and has a better chance of overcoming barnacle infestation and root burial problems (Tamin et al. 2011)	• All criteria have a good chance of being applied as long as Djibouti has educated, trained personnel involved with this project.
Pakistan	• Planning and collaboration of local institutes is necessary • Mangrove loss in Pakistan is due to reduction in fresh water supply, increased marine water pollution, over harvesting of mangroves and fishes, sedimentation, population stress, and coastal erosion • Reduction in freshwater supply increases the salinity of the water around mangroves and decreases the flow of alluvium brought by the rivers • Lack of public awareness about human activities that negatively impact mangrove forests is causing the deterioration of coastal ecosystems • Monitoring and follow-up are necessary parts of mangrove restoration • Local development needs must be linked with conservation initiatives (Mukhtar and Hannan 2012)	• Djibouti has a lack of governmental, institutional and legal capacity and therefore collaboration may be challenging. However, its small size and centralized government may make planning and collaboration somewhat easier. • Monitoring and follow-up will occur as long as there is good capacity of an educated and well-trained staff involved with this project.
Southeast Asia	• While ecological issues of are of prime importance, economic and social issues must be considered in the restoration plan in order for it to be successful • Local ecological knowledge is most important factor • Identify and address causes of degradation to prevent further degradation • Develop detailed guidelines for the executors of the restoration plan • Address anthropogenic influences by ensuring community participation. In Southeast Asia human influence on mangrove ecosystems is particularly significant • Encourage community participation by introducing economically sustainable livelihood alternatives (Biswas et al. 2008)	• Djibouti's government is seen as authoritarian in nature. Consequently, Djiboutians often do not have an opportunity to become involved in their government's activities. There may be a learning curve to entice and teach Djiboutians to participate in a mangrove restoration project.
China	• Many challenges were found with afforestation projects with survival rates being quite low • Suggestion to control invasive grasses by first using fast-growing pioneer mangroves and ultimately	• Having two different planting stages may be more labor intensive than the human resource capacity of

	replace with native species (Chen et al. 2009)	Djibouti can handle. It would be best to keep any restoration project as simple as possible.
South China	• There may be some benefit to using a different species of mangroves first in degraded habitats in order to facilitate future re-colonization by native mangrove species • Mangrove wetlands should be managed as an ecosystem • Long-term scientific monitoring is critical (Ren et al. 2008)	• See comment above (China). • Monitoring will occur as long as there is good capacity of an educated and well-trained staff involved with this project
American Samoa	• The stress or reason for degradation of mangroves must be determined prior to restoration efforts • Mangroves can self-repair but plantations may help to expedite the recovery • Understanding of the need for restrictions and support of stakeholders is necessary in order for the local community to be more likely to comply with restrictions on use • Successful restoration projects can occur with low-cost, non-technical techniques when the community participates and is supportive (Gilman and Ellison 2007)	• As Djiboutians are not accustomed to participating in government sponsored projects, there may be some hesitation to participating in a mangrove restoration project. Additionally, poor health may keep some Djiboutians from participating. Refer to Appendix A for more information on Health Issues and Healthcare in Dibouti.
East Africa	• The goal of the restoration project should be clearly identified at the beginning of the project • Afforestation projects may be necessary to provide much needed wood products to the local communities while other historical areas are reforested (Kairo et al. 2001)	• Both of these items would be very applicable to Djibouti.
Eritrea	• Mud flats may be used for afforestation projects if the trees receive an artificial fertilizer at a controlled rate to reduce the possibility of run-off (Sato et al. 2005)	• This type of project could be considered in Djibouti. Most important would be to implement a mangrove restoration project.
Philippines	• Best to replant in historical mangrove habitats • It's expensive and labor-intensive to plant in areas where mangroves did not historically grow • Enhancing existing mangrove forests may also be beneficial (Samson and Rollon 2008)	• These items are applicable to Djibouti.
Philippines	• Mangrove restoration most successful when completed in original mangrove locations which may be where there are currently fishponds • Use tenure of land as an incentive to involve the local community • Use a holistic approach • Poor survival usually attributed to either inappropriate species and/or site selection (Primavera and Esteban 2008)	• Most of these items would be applicable to Djibouti. However 100% of the forests in Djibouti are in public ownership. Therefore, it may not be possible to use tenure of land as an incentive unless ownership of the land were changed.
Florida	• Hydrologic restoration is key to successful mangrove restoration • Use a reference site and target final constructed	• Both of these items are applicable to Djibouti.

	grades to be the same as the adjacent undisturbed forest (Lewis and Gilmore 2007)	
Côte d'Ivoire	• Mangrove reforestation was most successful (95.66%) when accomplished with wildings (seedlings growing on the forest floor through natural regeneration) which were uprooted and transplanted • Restoration was also quite successful (75%) when floating-seedlings were harvested on the water (Egnankou 2009)	• Both of these items are applicable to Djibouti.

Sources: Tamin et al. 2011, Mukhtar and Hannan 2012, Biswas et al. 2008, Chen et al. 2009, Ren et al. 2008, Gilman and Ellison 2007, Kairo et al. 2001, Samson and Rollon 2008, Primavera and Esteban 2008, Lewis and Gilmore 2007, and Egnankou 2009.

Some common themes expressed throughout the case studies are that while mangrove restoration can be difficult, the difficulty can be lessened if the proper site is chosen where appropriate hydrological conditions exist or can be created or re-created. Often afforestation projects in areas that did not historically support mangroves failed; yet if hydrological conditions were designed to be similar to natural mangrove ecosystems, these projects could succeed. When completing a restoration or rehabilitation project within mangrove habitat that has become degraded it is critical to determine the cause of degradation and ensure that it has been rectified before proceeding with any planting. Community buy-in and participation is important not only during planting but also following restoration during management. Furthermore, local ecological knowledge was found by some to be one of the most important factors. High-cost restoration projects often failed while one low-cost, low technology project succeeded mostly due to high participation by the local community.

Similar to other projects in poor communities whose livelihoods are dependent upon local natural resources, community based natural resource management (CBNRM) has been found to be one popular approach to managing mangrove forests. Additionally, Adhikari, Baig, and Iftihar (2010) found that in Pakistan, co-management with the government rather than CBNRM worked best due to its governance structure placing less demands on social capital.

Mangrove management case studies in several countries throughout the world and the applicability of their findings to Djibouti are summarized in Table 4.

Table 4: Summary of significant findings of case studies regarding mangrove management and applicability of findings to Djibouti

Country	Significant Findings Regarding Mangrove Forest Management	Applicability to Djibouti
Pakistan	• It's important to retain the quality of the mangrove ecosystem as a decrease in quality would expose the poor to the worst effects of poverty since they depend on the goods and services provided by them • Investments in mangrove conservation make economic and ecological sense in Pakistan under a co-management regime with their government • Community capacity building and participatory approaches for co-management are necessary (Adhikari, Baig, and Iftikhar 2010)	• All of these items would be applicable to Djibouti. As indicated in the Project Identification Form (GEF 2008), poverty is found in many of the areas around mangrove forests and traditional coping mechanisms are no longer sustainable since they would previously use mangrove trees as an alternate source of livelihoods and use mangrove forests as a refuge for camels.
Tanzania	• Due to limited enforcement, policy failure, weak or dysfunctional state institutions, and little awareness and commitment, restoration and conservation initiatives are not very successful • Nationalization of mangroves has not helped in reversing degradation • Community members need to have ownership of forest, access, and right to use it • Local community buy-in and participation with the local government is required for an effective restoration projects • Societies dependent on mangroves must be allowed to use them in a sustainable manner in order for restoration efforts and management to be successful (Mangora 2011)	• All of these items are particularly applicable to Djibouti. The challenges found in Tanzania and proposed mitigations are very similar to those expected in Djibouiti.
India	• Community participation is key to successful ecosystem restoration • Different user groups are willing to contribute time and money in differing amounts for different reasons • It is critical to consider users' needs and perceived mangrove benefits in order to enhance community participation • Take into consideration socio-economic and caste differences across stakeholders and attempt to increase decision-making power of disadvantaged groups • Provide options to obtain services community members receive from the ecosystem (such as solar cookers in place of firewood collection) • Look for forest uses that could continue but that may be less invasive and that may take less time to renew • Approved restoration sites should be given long-term protection from future industry, power plants, government facilities, etc. to increase trust from local communities that the restored mangrove forests will stay intact	• As Djibouti is a poverty stricken nation, few of its citizens may be able to make an economic contribution. • While there is no caste system in Djibouti, it will still be important to enable the community members to have decision-making power and to encourage them to become involved in all aspects of the project. • It will also be important in Djibouti that the community members continue to be able to receive some benefit from mangroves while they are being restored. • Education about alternative livelihoods and about mangrove benefits will be

	• Education about alternative livelihoods and about mangrove benefits will be helpful in obtaining community buy-in and enforcement of protected areas (Stone et al. 2008)	imperative in Djibouti to garner community support and understanding.
Bangladesh	• Adoption of a "Sustainable Ecosystem Management," a holistic management approach, where biodiversity conservation and enhancement is a key management goal. • Facilitation of alternative income for local people by generating activities which are dependent on the forest is necessary • Reducing the local community's dependence on the forest • Coastal plantations are being developed to protect people from cyclones and to make the land more suitable for habituation • Coastal embankments are being planted and leased to poor settlers • Plantations developed on newly accreted mud flats • Enhance and promote recreational and tourism potential (Iftekhar and Islam 2004)	• Plantations would be an important aspect of a mangrove restoration project in Djibouti to provide alternative fuel wood. • Tourism near mangrove forests that does not degrade the ecosystem and that has ample opportunities for local participation could be another income-generating opportunity for Djibouti.
Thailand	Research on Pred Nai's CBNRM revealed the importance of the following factors: • Availability to funding to proceed in small, practical steps • A village savings group • Step-wise evolution allowing for capacity building • Interplay of leadership, community cohesion and NGO support • Leadership as key to grassroots movement • Partnership with a key organization for building capacity and establishing linkages • Horizontal learning among communities • Local ecological knowledge (Senyk 2006, p. iii)	• All of these items could be applicable to Djibouti. The small, gradual approach taken in this community would work well in Djibouti.

Sources: Adhikari, Baig, and Iftikhar 2010, Mangora 2011, Stone et al. 2008, Iftekhar and Islam 2004, and Senyk 2006, p. iii

Several important themes were revealed in the aforementioned case studies. First, in order to have community buy-in before, during, and after restoration it would be best if those who have traditionally had a need to use products from the forest continue to do so, but in a more sustainable manner to ensure that the mangroves are not being used up faster than they can be replanted and regrown. As indicated in the Tanzania case study, local citizens were found to have a need for a sense of ownership of the forest as well as have access and a right to use it. Furthermore, in those societies where there are caste differences and/or where there is an uneven balance of power, it is critical for everyone's opinions be heard and that the decision-making power be equitable according to the communities' overarching values and beliefs. In Djibouti women are beginning to obtain more power since a law has been passed that requires at least 10% of elected offices to be held by women. Therefore, it is anticipated that the inclusion of

women in mangrove restoration planning and management would be accepted in Djibouti, at least to some extent.

Having alternatives to provide the services that were previously gained from the forest, such as solar cookers, will help to lessen the demand on the mangroves. Additionally, education about the environmental benefits of mangrove forests as well as about alternative livelihoods will further enhance support from the local community. Lastly, mapping and monitoring before, during and after restoration is critical to be able to regularly survey the site and to track progress. However, due to the often large size of mangrove forests, remoteness, and rapid changes, both mapping and monitoring is often quite difficult. While traditional aerial photography has been historically used, more recently it has been found that the use of satellite imagery is better suited for capturing imagery of mangrove forests. It enables forest managers to quickly map and monitor their mangroves (Walters et al. 2008, p. 229).

Additional Factors to Consider

A review of the literature regarding mangrove restoration and management revealed several other important considerations when planning a mangrove restoration project. These sections are provided to expand upon some of the findings noted in the previously cited case studies or are provided to detail additional information and criteria that is important for Djibouti to consider.

Additional Environmental and Scientific Factors

Gilman and Ellison (2007) found that there are several environmental conditions that rehabilitation sites must meet that are required by mangrove species indigenous to the area to be replanted which are more specific than those mentioned in the tables above. These would include duration, frequency, and depth of inundation, wave energy, substrate conditions, salinity regime, soil and water pH, sediment composition and stability, nutrient concentrations, elevation and slope. Furthermore, they found that mangrove rehabilitation is likely to be more successful at a site where the disturbance has been recent, so that there is an opportunity to stop it and mitigate impacts, and where the disturbance is minimal.

Table 5: Specific Environmental Criteria for successful mangrove restoration

Criteria	Specifics
Elevation	• Site must be graded to the elevation that provides the optimal hydrologic regime for the targeted mangrove species
Slope	• A gradual slope assists in reducing erosion, reducing filters runoff from entering the wetland, and allows for surface drainage at low tide
Tidal Exchange and Wildlife Access	• Drainage channels may be necessary to stimulate natural tidal creeks to provide the necessary tidal exchange, salinity regime, and wildlife access
Wave Energy	• An offshore structure may be necessary to reduce the wave energy if the site is exposed to wave energy which is too high
Fertilizer	• Time-released fertilizer may be necessary

Fencing and Removal of Loose Debris	• The risk of disturbance by humans, domestic animals and wildlife can be reduced by the installation of fencing • Dead trees or other garbage should be removed which could damage the rehabilitation area

Source: Gilman and Ellison 2007

The failing of mangrove restoration projects can be attributed to two factors according to Lewis and Gilmore (2007); a misunderstanding of mangrove forest hydrology and/or a false assumption that in order to achieve a fully-functional mangrove forest ecosystem all that is needed is to simply plant mangroves without incorporating some of the important considerations previously mentioned. These authors found that fish habitat needed to be incorporated into tidal hydrology in order to provide access and low tide refuge for mobile nekton. Three strategies for obtaining optimum fish habitat were suggested: achieve plant cover similar to that in an adjacent, relatively undisturbed and mature mangrove ecosystem; establish a network of channels that mimics the shape and form of a natural tidal creek system; and establish a heterogeneous landscape similar to that exhibited by the local mangrove ecosystem (Lewis and Gilmore 2007, p. 829).

Additional Economic Factors

Impoverished countries such as Djibouti will need to rely on financial support from their governments as well as from NGOs, the donor community and multilateral organization for the implementation of any mangrove restoration project. However, restoration and management plans should focus on the development of a self-sustaining mechanism so that it will reduce the need for relying upon continuous financial support from the outside community. This will enable the local community to sustain its livelihood and restoration efforts indefinitely into the future (Biswas et al. 2008). Furthermore, financing for basic inventory research, preventative problem-oriented research, conservation-rehabilitation activities, and future monitoring should be secured (PERSGA 2004b).

It is also believed that if mangrove resources were efficiently managed, they could generate sufficient income to pay for their own management (PERSGA 2004a). Sources of funds could include the sale of mangrove products, entrance fees from Marine Protected Areas, fees for limited camel grazing, licenses for utilizing the areas such as for taking photographs, fishing, and conducting research, sales of TV documentaries, books, images, CDs, etc. and fines from illegal activities and for compensation due to mangrove destruction (PERSGA 2004a).

Additional Social Factors

A mangrove restoration project in West Africa supported by the Netherlands Committee of the World Conservation Union found that allowing community members to plant vegetable gardens in the spaces between small, growing mangrove trees during a mangrove restoration project provided food and income for the local families while they were waiting for the mangroves to grow to an age that they could begin harvesting them. This provided greater support for the restoration project from the local community (World Rainforest Movement n.d.).

An important suggestion made by FAO (2007) in planning for a mangrove restoration project is to ensure that technical training is provided to those that will be implementing the project. This is a crucial lesson that was learned from the post-tsunami experience in Thailand. After a large-scale effort to plant mangroves was made, the end result was that many large stands of mangroves were planted in sub-par conditions and consequently did not survive.

Regarding CBNRM, Borrini-Feyerabend et al. (2004) found that in order to be successful, local buy-in is necessary. Moreover, what is also needed but often forgotten is to assess the concrete ability of people to actually become and stay involved. They go on to explain that often those wanting to participate are limited since they have had difficulty meeting their basic needs resulting in their being perennially sick. This is an ongoing challenge for Djibouti especially in light of their limited healthcare (see Appendix A for more details). Often times community members may become depressed due to multiple disasters within their families. Lack of transportation and/or lack of time could also be responsible for making it difficult for community members to attend or participate in meetings. Furthermore, beyond the need to educate those participating in CBNRM, the authors found that there is a need for a "learning attitude" which is the openness to novelty, the willingness to experiment, and the curiosity that motivates people to carry out action-research, which is active research initiated by a community or individuals to solve a problem and participation in the necessary change (Borrini-Feyerabend et al. 2004, p. 428-429).

Additionally, while many in the past have believed that projects that aim to conserve biodiversity and promote human well-being always result in a win-win solution for all stakeholders, more recently studies show that instead, communities must evaluate different trade-offs between these two goals. It is rare that conservation initiatives have realized outcomes that both conserve biodiversity and also achieve poverty reduction for the local people. Consequently, McShane et al. (2011, p. 970) suggest that "trade-offs and hard choices involved should be assessed, discussed, and debated in an honest and sober way."

Additional Legal and Political Considerations:

On 15 November 2012 a field professional with knowledge of Djibouti indicated to this author that the Government of the Republic of Djibouti prefers that specific information about the country not be known by the outside world. For instance, this professional indicated that GORD is sensitive about other countries knowing the population size of Djibouti in addition to other statistics about the country. Information provided by this professional also indicated that since there are so few GORD employees and since the majority of these employees work in the same building, there was discomfort in discussing details about the government or country. Consequently, there was hesitancy to share specific information about Djibouit. Furthermore, this professional indicated that some statistics that were sought for this paper, such as the number of citizens that are dependent on mangroves, were difficult or impossible to ascertain.

As indicated earlier in this paper and in the 118/119 Assessment for Djibouti (Appendix A), many citizens in Djibouti have little to no trust in GORD nor do they have much confidence in the electoral process. This would be partially due to the following reasons: Djibouti is an authoritarian government with a one party state; a unilateral Presidential Decree exists which is used to make many laws and policies without input from other sectors of the government or the public; and GORD maintains restrictions on licensing and operation of broadcast media.

Consequently, lack of trust may pose a challenge to obtaining community participation and engagement in conservation projects.

Other Considerations:

While the sustainable use of mangrove forests has been presented earlier in this paper, an additional consideration would be to break up mangrove forests into zones where one area would be protected, perhaps during a restoration project or after some type of destruction, and another area could be available for some limited sustainable use. This idea has been shown to help reduce pressure on the mangrove forest (Iftekhar and Islam 2004). Furthermore, Ostrom (2010) summarized a study by David Barton Bray and colleagues whereby they found that there was a very low incidence of net deforestation in forested landscapes that were productively used. This was in contrast to high deforestation rates and fragmentation that were found in protected areas where indigenous people were required to move and were no longer allowed to use the forest. Ostrom (2010) also discussed a study by Jeremy S. Brooks et al. who found that allowing local users to harvest and sell some products was an important factor for a successful outcome.

Due to the high degree of connectedness of the coastal and marine ecosystems in the countries located in Red Sea and Gulf of Aden, PERSGA recommends an integrated coastal zone management planning effort for mangrove conservation (PERSGA 2004a). This is partially due to the fact that mangroves occur at the land-sea interface and consequently are sensitive to changes in coastal land-use patterns. Therefore, one of the objectives of PERSGA is the "implementation by all participating nations of Integrated Coastal Management Planning for conservation of mangroves and associated coastal habitats and species, supported by appropriate legislation, land-use planning, participatory approaches, socio-economic and environmental impact assessment, monitoring, and enforcement" (PERSGA 2004a, p. 4). Some important aspects of their proposed Regional Action Plan include the involvement of all stakeholders; harmonizing of the resource use among stakeholders; development of flexible and adaptive management systems that respond quickly to new information; assurance of high levels of information-sharing and technology-transfer across all scales of implementation, and among all participants; and adoption of a precautionary approach to any future development issues affecting mangroves and associated coastal habitats (PERSGA 2004a, p. 27).

Spalding, Kainuma and Collins (2010, p. 41-42) support the idea of zone management by indicating that establishing networks or systems of protected areas within or between countries is now seen as a way of building resilience and encouraging more rapid response to extreme impacts. When deciding upon the boundaries of these protected areas the location of adjacent ecosystems that may be linked to mangroves must be taken into consideration. Furthermore, effects outside of the ecosystem such as the management and protection of the inland watershed are important and most beneficial when these areas are well managed and/or part of the protected complex. Additional protection is gained when these areas are designated under international conventions such as the World Heritage Convention, the Ramsar Convention, and UNESCO's Man and the Biosphere Programme. Not only do these areas receive prestige as a result of their designation but they also receive greater scrutiny to ensure that they are being managed appropriately. NGOs and partners will often put pressure upon those nations not maintaining and protecting these designated sites which may lead to financial and technical support when necessary (Spalding, Kainuma and Collins 2010, p. 41-42).

Furthermore, Spalding, Kainuma, and Collins (2010, p. 40) highlight the cases of Kenya and Malaysia where all mangroves fall under state ownership and are managed as forest reserves. While this has not completely prevented exploitation, it does at the very least provide a management framework which can allow limited, sustainable silvicultural practices.

Stone et al. (2008) analyzed factors that influence a household's willingness to contribute toward mangrove restoration using the contingent valuation technique to measure the economic value of perceived benefits of mangroves. This analysis allowed the authors to more clearly define the needs of the community and perceived mangrove benefits prior to initiating a restoration project which could result in enhanced community participation.

Lastly, Van Lavieren et al. (2012) discussed how a community's legal title and right to use and manage mangrove forests is a key to successful mangrove management. They explain how there is tension between local communities and official institutions when a community is not given legal tenure, use, and access of mangrove forests. Consequently, this will be a challenge for Djibouti as currently there is only public ownership of forests with very limited use allowed.

Recommended Criteria and Conditions for Djibouti

The majority of the criteria and conditions that have been discussed thus far could be applied to a mangrove restoration and management project in Djibouti. However, based on the current political, economic, environmental, and social circumstances, the following would be considered to be the most important:

1. As much as possible, the following threats to mangrove ecosystems must be addressed to prevent further degradation: habitat degradation mostly due to camel grazing and the illegal cutting of mangroves; pollution mostly due to domestic solid waste and sewage: lack of a skilled workforce; and limited governmental, institutional and legal capacity. This limited capacity makes the enforcement of appropriate regulations, monitoring of ecologically sensitive areas, and the implementation of conservation programs more challenging. Improved institutional capacity would allow for better infrastructure to deal with solid waste and sewage.
2. Understanding of the importance of regional and international conventions and the ecosystems that they aim to protect as well as the laws, regulations, orders and decrees that Djibouti has in place to protect coastal and marine environments. Education of communities that live near mangrove forests about the reasons the forests have become degraded, the social, environmental, and economic benefits of healthy mangrove forests, and the consequences of their loss will be a critical component of conservation efforts in Djibouti.
3. Designate protection, and enforcement of that protection, of some portions of the degraded mangrove forests so that they can be restored. This will involve improvement of governmental, institutional and legal capacity in Djibouti. However, limited use of some of these protected areas should also be considered, such as for camel grazing.
4. Encourage community participation in all stages of mangrove restoration and management. Learn about the local ecology of the mangroves from the community and apply this to a forest management program. However, acknowledge the potential trade-

offs for the community, address these with the local population before-hand, and develop mitigations, if possible.
5. Consider afforestation or plantation projects in addition to restoration projects in order to provide necessary fuelwood to the local communities.
6. As much as possible restoration projects should occur in historical mangrove habitats and the elements of the ecosystem should mimic similar ecosystems close by.
7. The restoration of hydrological connections is one of the most important aspects of mangrove restoration.
8. The use of wildlings which are uprooted and transplanted gives the best chance for a successful restoration project.
9. Provide alternatives to the use of mangroves, such as solar cookers, so that the community has less reason to rely on the forests. Brainstorm with the community to identify alternatives for other economically sustainable livelihoods.
10. Partnership with a key organization, such as IUCN NL, for building capacity and establishing linkages. Financing is needed in order to complete a good inventory and to ensure that future monitoring can occur. A good inventory of mangroves can be obtained through the use of satellite imagery. This will also enable more effective monitoring.
11. Best to start with a small, low-cost project and proceed slowly and cautiously.
12. Ensure technical training is provided to those implementing the project.
13. Work with other countries within the Red Sea and Gulf of Aden in implementing an Integrated Coastal Zone Management effort. This should include: coastal zone management activities; incentives for fisheries conservation; and institutional arrangements for sustainable programs, including revenue-generating mechanisms for services such as coastal erosion prevention and marine protected areas (FAO 2007, Chapter 4, p. 11-12).
14. See Table 5 for specific environmental criteria.

Conclusions

As indicated in the FAA118-119 Analysis, Djibouti has many opportunities to conserve biodiversity. One such area is mangrove restoration. While rehabilitation of a degraded mangrove ecosystem can be challenging, if certain criteria and conditions are followed, such as proper site selection and restoration of hydrological connections, often the mangroves can come back virtually on their own.

Providing a right to access and to use mangroves on a limited basis as well as possibly providing limited tenure rights could help to incentivize Djiboutians to use the forests in a manner that would reduce exploitation and degradation. It could also help to garner public support in the restoration and management of the forests.

It would be best for any project to be of smaller scale and start out slowly with much involvement from the local community to make sure that their day-to-day needs are met during the restoration and to ensure that local ecological knowledge is used during planning. Protection and enforcement of that protection should be put in place for the area to be restored as well as possibly for portions of other mangrove forests. However, it will be important to also leave some areas open to sustainable use such as minimal cutting and camel grazing.

A successful mangrove restoration and management project will enable Djibouti to reach some of their conservation goals which include the alleviation of habitat degradation, conservation of biodiversity in-situ in zones of ecological significance, reducing the threats to mangrove ecosystems, reducing the rate of biodiversity loss, maintaining the integrity of ecosystems, and addressing threats to biodiversity. However, based on limited and conflicting information regarding the support and commitment of the leadership in Djibouti it is unclear whether or not Djibouti has the capacity for a large scale mangrove restoration project along with successful long-term management. Buy-in and participation by the local communities, which has been found to be one of the key criteria for successful mangrove restoration, may be difficult to obtain due to their being strong distrust of the government and a lack of understanding about the important ecosystem services provided by mangroves. Additionally, in the past the government has ratified numerous treaties and has committed to implementing quite a few conservation projects yet implementation, follow-through, and completion has often been lacking. If GORD were able to successfully implement several small scale restoration projects it could help to show bilateral organizations, multilateral organizations, and NGOs that they are serious about their desire to work toward conserving its biodiversity. Consequently, these organizations may be more apt to provide the financial support in the future to enable Djibouti to implement a larger-scale mangrove restoration initiative.

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